Menlo Park Notebook #23 [N-79-01-19]

The dated entries in this notebook cover the period January-February 1879. The earliest entries may be from December 1878. Most of the entries are by Edison, Charles Batchelor, and Francis Upton. There are also entries by John Kruesi. All of the material relates to experiments on electric lighting. Included are notes on metals for filaments; calculations and drawings of generators; and notes and calculations about electric power distribution systems. The book contains 152 numbered pages. Following page 33, the left-hand pages are unnumbered.

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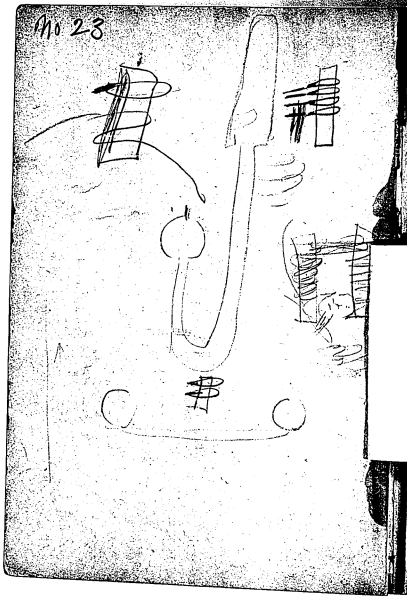

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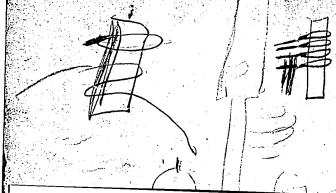
important

No 23



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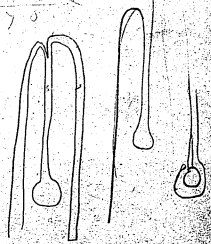

1000
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360 : 640 :: 3 : Ans

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3250
40

~~5.1 Ohms~~ 5.9 Ohms

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444 : 556 :: 4 : Ans
111
356
556
556
6.1716 6.1 Ohms

1000
459

489.511 5.2 ans

459) 2385 (5.2
2295
1100

476) 5244 (5 ans

476) 2620 (5.5
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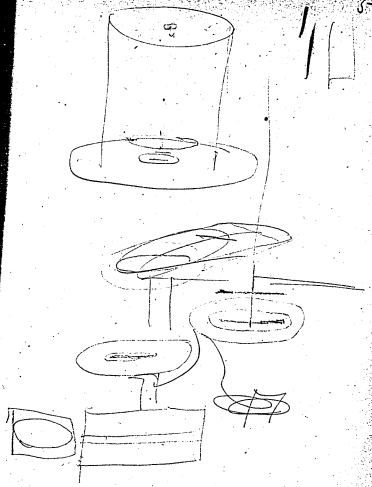
20



6

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817 | 183 | 30 | ans

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017 | 5490 | 6.7 ohms
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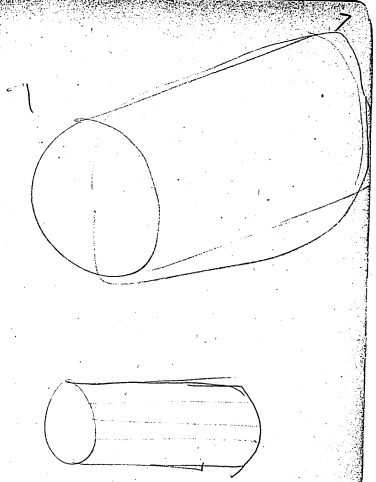

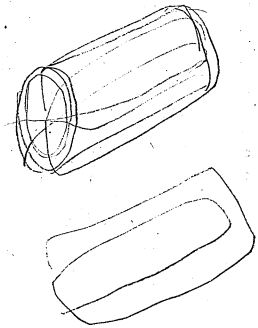

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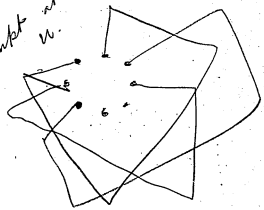

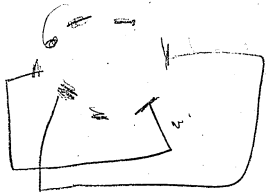

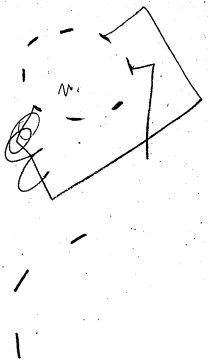

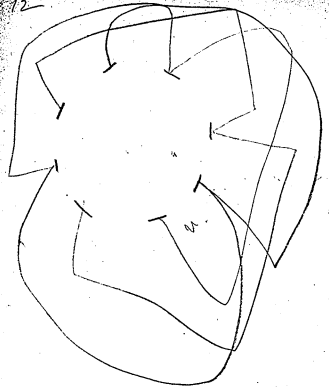
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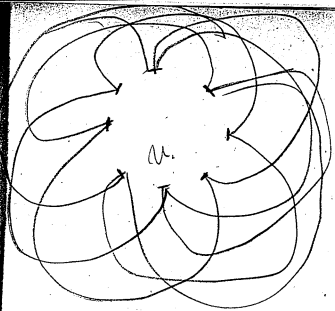
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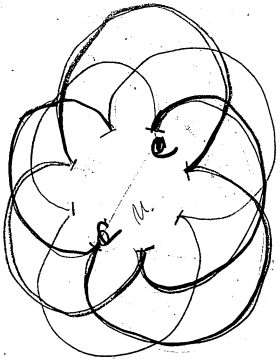
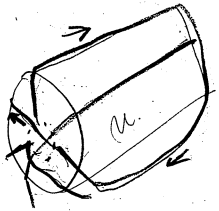
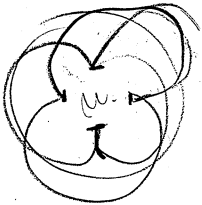
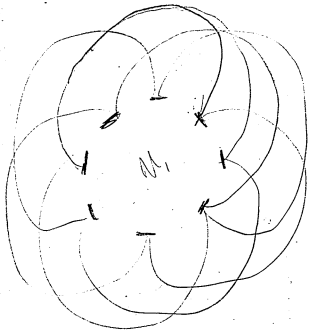
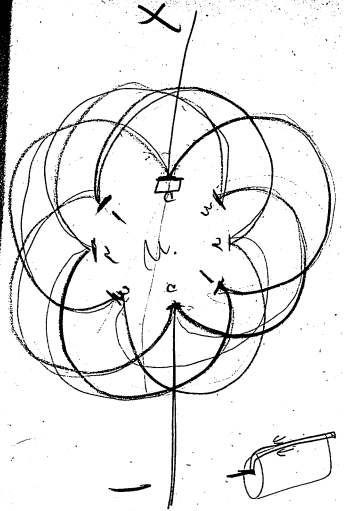
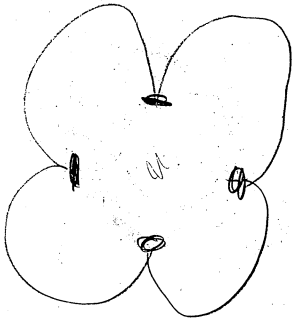


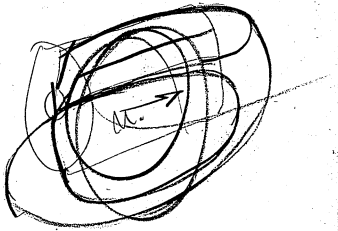


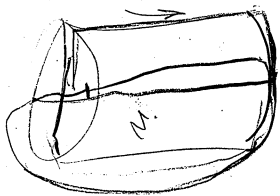


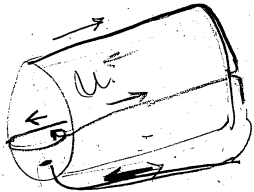












R resistance of ring 25 Ohms
field map 50 Ohms
75 Ohms
75 Ohms
150
10

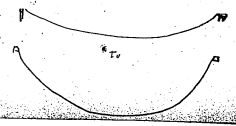
Ex turn

$\frac{50}{150} = \frac{1}{3}$

Experiments with Platina & Platinum-Iridium alloys 20 per cent Ir – at the incandescent point with galvanic battery to determine any changes that may take place.

Menlo Park NJ January 18-79

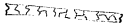
Platina wire 004. does not permanently elongate to the extent that the pt-Ir-alloy does, the latter is very soft at the incandescent point so much so that with 004 Pt-Ir wire 20 pc is unable to support its own weight when placed horizontal between supports 80 mm. apart. it slowly bows downward from a slight curve thus



It has not anything like the strength of platinum even at the same temperature.

When the Pt-Ir wire is allowed to remain incandescent for 30 minutes a remarkable change is effected. It stretches, grows smaller in diameter (10) from 004 to 003. & breaks upon examination under the microscope it has this appearance

Platina wire thus



If the platina wire is only brought to incandescence for say 2 minutes it shews these cracks

they first are not open but just as if a mole had been burrowing around the wire, after a longer time these break & sharp edged cracks make their appearance;

when the Platinum wire is fused after being cracked the piece upon the end when it does not break off short has this appearance;

Just before Pt or Pt-Ir wire fuses between the supports it contracts violently and the

cause is apparant when we place it under the microscope. it has drawn up into globules if it breaks quickly the globular tendency is just perceptible but if it contract considerably before breaking these globules a plain

To ascertain loss of weight we placed .005 pt wire in supports weight 0.0296 gramme. in 5 minutes we raised heat so it fused upon weighing the whole it was 0.0293 g showing loss .0003 gramme.

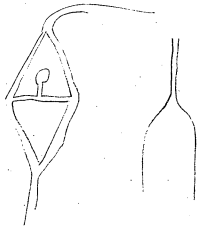
Another piece weighed 0.0266 after being measurement for 20 minutes it weighed 0.0265. showing loss of .0001 g. at

this rate it would all be dissipated in 122 hours, but organic matter may account for some of this loss.

The same piece was then made incandescent for 20 more minutes and weighed 0.0262 grammes shewing a further loss of weight of 0.0003. or a total loss of .0004. gramme.

after 10 minutes more we again weigh it and find weight to be 0.0260 shewing a further loss of weight of 0.0002 or a total of 00006. gramme.

After 20 minutes more we again weigh it and find its weight to be 0.0258 shewing a further loss of 0.0002 or a total of 0.0008. gramme.



Yesterday I noticed a peculiar phenomenon when the platinum of 004 wire was placed between the supports 50 mm apart and brought to incandescence for 1 hour a portion only was incandescent after the lapse of that time. thus

With large Eaton's spectroscope no lines were visible, but perhaps if longer wire were used lines could be seen – It is barely

possible that the platinum is contaminated with osmium, Ruthenium, Rhodium or other more oxidizable metal of the platinum group - or that there is an immense amount of oxygen condensed in the platinum which is driven out by the heat,

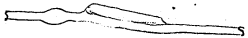
I think that I smell ozone coming from the incandescent wire, at least the smell is peculiar,

Another hypothesis is that chloride of sodium in the air combines with the Pt to form a volatile Pt chloride,

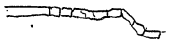
I find that the 001 wire made (pt) by Johnson Matthey & Co London melts in the ordinary gas jet - under the Microscope it shews all broken up in short lengths and clearly fused at these breaks a piece of wire held in the flame bends with a jerk thus

with wire 002 made from Raynors pt. it fuses readily but these short breaks are not so perceptible as in J M & Co wire. all the breaks are smooth

thus



whereas J M wire



with Rayrow of 010 pt. after being incandescent 5 minutes on battery, showed fine cracks just commencing, but the sections bounded by the cracks were very much smaller than JM.T.Co small 004 wire,

I now put in 010. 10 p.c. Pt Zn - JM&Co wire, - taken out and experiments

resumed with the piece which we have repeatedly weighed-

I notice that this piece does not drop or bow downwards nearly as much as it did when first put in- There is just 70 mm of this wire, after 3 minutes I notice it commences to drop considerable-

With platina wire I notice that the heating always commences exactly in the middle of the wire and reaches towards the two supports simultaneously but the action is not so rapid but that the eye can easily trace it.

J M & Co 005 platina if held in gas flame for 30 seconds shews cracks under microscope; also little round raised

75 - after

drops as if gas were underneath but tension was insufficient to burst the bubble.

= heated air can be seen rising from 70 mm of 004 wire 2 feet over it =

The 0.0266 wire after resubjected again to incandescence for 20 minutes weighs - 0.0252. showing a loss since last weighing of 0.0006 or a total of ~~0.0014~~ .0014.

It was again made incandescent for 20 minutes & weight found to be 0.0249. showing loss of 0.0003 or total of 0.0017. The wire fused.

we now take 1/2 of this fused wire which weighs 0.0132 grammes and subject it to incandescence again for 60 minutes continuously -

note - I notice the wire although growing smaller keeps perfectly bright.

The loss in 60 minutes 0.0130. or .0002, This loss is not very great but may be due to the fact that I put a book up on one side of the wire within 1/4 inch of it to shield it from air drafts which cooling it in spots raises the temperature of the rest of the wire by reducing resistance & this tends or sometimes causes fusion

we again put the wire to the incandescent point for 20 minutes, It weighed

[note. I did not succeed in fusing the 001 wire in flame from burning paper though it became incandescent.]

afterwards ·0129. shewing loss of ·0001

after 20 more minutes of incandescence it weighs 0·0129. shewing No loss

The scale (Beckers best) does not work as sensitive as it should be. We again put it to the incandescent point for 20 minutes and I take the book down to allow draughts of air to strike the platinum as it is not highly incandescent, and if the action is due to oxygen this will hasten it. we weigh & find no loss –

we again bring it to the incandescent point, slightly higher than before for 20 minutes – we weigh and find NO LOSS I now at 7 o'clock pm bring it to incandescence to be left all night.

Menlo Park. Jany 20=79

Found that battery had run down on platina cold. It probably kept incandescent for 2 or 3 hours then by midnight became invisible we find at 8.30 am this morning on weighing that it had lost nothing = We again bring it to incandescence for 1 hour. note – I notice a flash of smoke go off when the Pt was heated this morning showing that dust had been deposited over night. the weight

must have been very small,

after one hour it weighs <u>no less</u>

<u>note</u> - The whole loss of this piece with the one broken from it amounts to 8.4 per cent. 4 hours & 20 minutes then stopped looking —

one hour more <u>no</u> change.

I placed a piece of Pt-Ir 10 per cent foil in stand and brought to incandescence for 2 minutes, under microscope. it showed slight cracks

thus.

and some of the surface of the foil bounded by these cracks showed a tint of iridescence.

I again brought the foil to incandescence for 5 minutes, under the microscope the

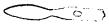
cracks were large and spotted all over with sections that were viridescent. thus

This shews oxidation and I think it is Iridium often causing it to become incandescent for 5 more minutes. these viridescent spaces lose their fine appearance and approach that of the viridescence of lamp black. the viridescence is blue & ultra violet.

Palladium becomes incandescent and I think melts at about the same temperature as platina, It become greatly annealed, do not see any viridescence

notice that hair points on strip have melted,
with the 0.0132, which weighed 0.0129.
By 2 hours more heat it loses 0.0004
(18) goes to 0.0125. we put on a fresh
battery but this did not make it move
incandescent as we used 1 cell less
unfortuniately on putting it in stand
again it fused. under the microscope:
the sharp edges of the cracks are rounded
they have not materially increased
the core is as bright as ever. The
end is a beautiful ½ globule very
smooth. thus

I notice what appears to be an air bubble thus.



I noticed on taking away from the stand that under the microscope a large piece of some salt, or organic matter was attached to it. This might have caused the fusion by reducing the temperature at that point.

I again put the palladium to mouffle for 15 minutes, under the microscope the whole surface is crystalline, showing the crystals perfect these are fine crystals. Look like Antimony. They do not

Iridesce like the Iridium in the Pt-Ir alloy = between the crystals something has apparently been eaten away as the top & bottom of crystals require a different focus of the microscope. These crystals can be seen with the naked eye, = crystals may be thrown upwards = prisms.

I now having broken one small 0.0132 piece I substituted for the battery the Gramme machine, and use 410 mm of Raynor's Pt wire, which I have flattened out so as to be nearly 3/16 wide, I brought it to incandescence for 3 hours. Its first weight after

Cleaning by a momentary incandescence was. 0.3430. after 3 hours it weighs 0.3210

Gold cannot be brought (00Z wire) to red heat at least cannot see it in daylight (fuses) –

Ruthenium is precisely the impurity in platinum because it quickly increases and becomes viridium, while ~~platinum~~ viridium does not appear to, Iridium (pure) keeps bright, Rhodium becomes viridium but not near as

much as Ruthenium,

Upon putting Iridosmine to incandescence it becomes covered with crystals which shoot out from it + look like crystals of permanganate of Potash to the naked Eye. they indeed look beautifully

Everything about Ruthenium looks wonderful & resembles fused Carbon. I also notice these long needle like crystals + I think they are either osmium or Ruthenium.

oxygen has no other effect than to cool the wire like wind, It looks as if platinum was volatilized at a high temperature = The 410 mm wire after 1 more hour weighs 0.3103

When Pt-Ir wire has been in the Hydrogen flame for 1/2 an hour the green coloration disappears but by increasing the battery current passing through it. It again appears, of course the extra battery raised the temperature

The first cell having polarized

we put the 410 mm wire 1 hour more under incandescence it weighs 0.3075.

we incandesce it again for 1 hour and find that it weighs 0.3050.

we again put it to 1 hours incandescence after which it weighs 0.3018.

= note - I notice that Bichloride Platinum colors flame ultra violet or greyish violet, also green at the edge. This may be due to vapors of platinum -

we broke the 410 wire 1/2 weighs 0.1474. after 1 hours incandescence it weighs 0.1474.

I seal a piece of iron wire in glass tube and I find that I can bring it to a bright yellow color, when the tube broke, I find that the oxidation skin is very thin, owing the expansion of the iron in the glass it touches and fuses the latter.

we put the 1/2 of the old [illegible] in and bring to incandescence. it weighs cold 0.1541. It [illegible] =

we now roll out a piece of 20 pc Pt-Ir alloy .020. and after bringing it to incandescence we weigh and find weight to be 1.0147 we then put it to incandescence with dynamo machine. There is about [illegible] mm & [illegible] about $\frac{1}{16}$ wide – 1 o'clock & 20 minutes PM January 22 1899 –

I find this coil has been rolled thinner on one side, about ½ of it is brilliantly incandescent while the remainder is yellow white – This piece burned last night at 7.20. after having been incandescent for 6 hours. It weighs [illegible] 6 oz. [illegible]

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0.9188. Under the microscope you find that the cracks are still visible but within the cracks are innumerable holes with a crater like appearance. The whole wire is now covered with the naked eye has the appearance of frosted silver, one of the parts I cut off 3 wires the weight after weighing it has the old appearance, it is bright. We weigh and find that it weighs 0.3527.

time. 10 30 am. after being partially incandescent at 3 o'clock PM it weighs 0.3325 gramms. The end which was incandescent the most is greatly honeycombed, The proves that platinum volitilizes at at yellow and probably at a red heat and that the green flame seen when heed in hydrogen flame is volatilized Pt.

We now commence some experiments with the oxyhydrogen flame, to determine fusing points of non. conductors and metals. We make a rough guess as to fusibility by noticing the time and trouble it requires to fuse the substance

Platinum fuses quite readily- Rhodinium fuses easier than Platinum. Ruthinium does not fuse but something volitile comes off which colors the flame and the piece becomes light and porous.

Iridium does not fuse or color the flame or appear to get smaller. I will mention that the gases are not mixed before

consumption, the gases are burned from the orifices of two common blow pipes. Iron instantly melts and oxidizes but I think the extra heat due to its oxidation is the cause of its melting. Cobalt is very difficult to melt, it oxidizes slightly. Nickel is exceedingly difficult to melt and I think it has as high a melting point as platinum and possibly higher if fused in a vacuum and prevented from oxidizing - a globule of nickel in molten state was brilliantly incandescent and did not appear to oxidize or grow smaller. Silicium does not fuse but at a certain temperature ~~and~~ it oxidizes with explosion

Boron does not fuse or apparently oxidize.

Aluminium becomes incandescent without oxidizing or melting but if the oxygen pipe be brought near it it instantly oxidizes –

Rutile is fused with exceeding difficulty it is a conductor both before and after fusion, after fusion a small piece thus. x. has with powerful pressure a resistance of 62 ohms when powdered and a platinized block pressed upon the powder it had a resistance of 17 ohms

Metallic Zircon oxidizes at very high temperature. becomes coated on outside with white oxide -

Metallic Chromium from Johnson Mathay & Co does not fuse that we can see, we get a current through it after fusing and by great pressure bring it down to 18 ohms

The chromium from Brooklyn given me by Beardsley is slightly attracted by the magnet showing iron - It fuses tolerably easy. The fused mass probably an oxides. Its resistance by great pressure is 20 ohms -

We now mould up a block of Titanic Acid for fusion in the O.H. flame, we find that it fuses at very high temperature, and the moulded piece contracts and cracks, owing to the volatilizn of the (something - = It does not conduct: It has in places a vitrous appearance color azure:-

Alloy Titanic Acid, Nickel = do not appear to mix -

Alloy Iron & Nickel. Iron burns up but think some has alloyed with the nickel, resistance of a button 1/3 ohm its to thick = ds very brit

Molybdenum all goes off in fumes.
Chromium & Nickel do not alloy as we cannot perfectly fuse the nickel or touch the Chromium, I notice Chromic colors on lime shewing oxidation.

We take a piece of nickel and roll it out cut a narrow strip and pass a current through it and very strange to say it becomes brilliantly incandescent with fusing. I think it nearly if not equal to platinum – It slowly oxidizes but we shall prevent this by sealing the burner = when it does fuse it acts like the Pt-Ir 20 pc alloy — it remain hard when incandescent.

It is very probable that absolute chemically pure nickel will have a very much higer fusing point than the sample we have which is probably only commercial. This is a great discovery for electric Light — in the way of economy
Jany 24 1879.

Batchelor has succeeded in rolling nickel in sheets .002 thick. the piece was somewhat crack.

With another piece he has rolled it without a flaw or crack .003. and is now going to roll it thinner between steel plates; his success is due to annealing after each rolling -

a piece of 00z nickel is brought to yellow heat for 10 minutes on Gramme machine when it melts in a weak spot – a perfect globule is upon the end of the broken part – upon bending it gives a crackling sound shewing considerable oxidation – it is black & shining just like Russia Iron.

This oxide is extraordinarily tenacious the nickel may be bent several times nearly at right angle without shewing cracks in the oxide, but if bent 20 or 30 times exceedingly fine cracks may be detected under the microscope.

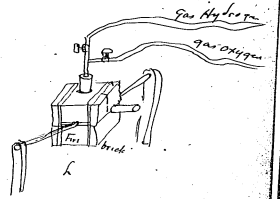
we have now rigged up a regular Oxy-Hy blowpipe like the lantern blowpipe. We melt in two minutes a pin head of Iridium (I+M) - on flat lime - Ruthenium boils at once something goes off leaving a porous something which is infusible, Osmium Iridium - (Iridosmine) is infusible. but something comes off but not a great deal. nickel is not very easily fused it only fuses apparently when it oxidizes Chromium is a little harder to fuse than nickel - after fusing nickel it is quite malleable.

Osmium-Iridium after 1 hour with the O.H. flame does not fuse

January 27th

Last 3 days been arranging our apparatus for conducting experiments –

With O.H. Batchelor is now experimenting



Lime crucible inside –

I have rigged up two carbon points with the gramme machine and concentrate the arc in a lime crucible -

Melted Nickel and preserved it in bottle for future experiments - also alloy Ca + Ni also Ni + Fe. also large quantity of Fe with small quantity Ni

Owing to the enormous power of the light my eyes commenced to pain after 7 hours work and I had to quit.

Jany 28 1879

Suffered the pains of hell with my eyes last night from 10 pm till 4 am when got to sleep with

$\frac{365}{109.50}$

1 Machine. 1 ohm internal 1 external

100 000 ft lbs per minute. 50 000 in 50 000

Cost of machine, $100.- cost of power,

3 cents per hour 30 per day per year $109.\frac{50}{100}$ – cent 12.

for 50 000 ft lbs $120.

4 machines. 4 ohm. 32 external –

$109.\frac{50}{100}$ lbs. 2 $\frac{00}{100}$ inside 84 $\frac{00}{100}$ outside. –

$100.\frac{50}{100}$ – for 84.000. interest 40 – makes

$150 for 84,000.

$120 – for 50.000 2 40 per M.

150 " " 84.000. Sub-marine [illegible] 78.000.

Latter 1 $\frac{92}{100}$ per M.

a big dose of Morphine, eyes getting better & do not pain much at 4 PM – but I lose today =

Zirconium – (metal ?) scales ~~in~~ good.

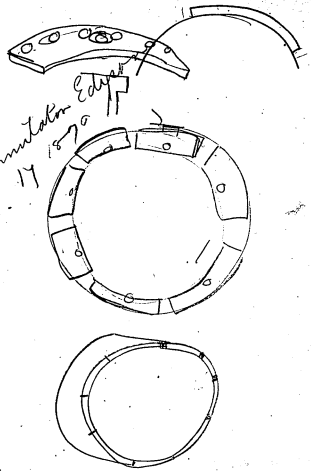
Conductor

In fusing nickel the button is never apparently covered with an oxide still there is a thick shell of something that is infusible covers the molten globule. yet when I take it out, it appears to be metallic nickel. There is something very curious about this matter.

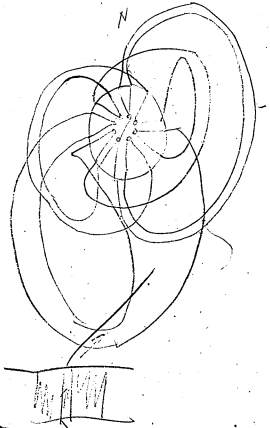
January 29. 1879

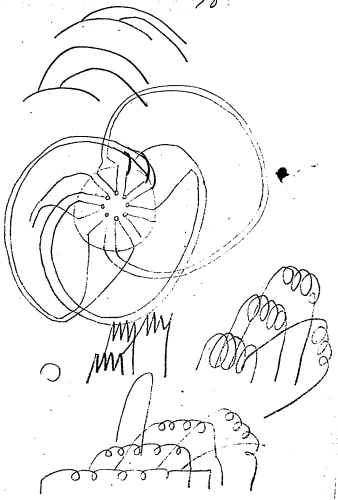
I am now grinding. Magnetic oxide of Iron to a fine powder for moulding in a stick =

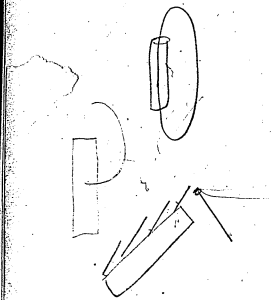
oxide cobalt on OH. fuses and combines with the lime and makes an infusible semi metallic compound. Grills but hard to break & a non-conductor = combined with some magnetic Iron oxide doesn't alter its properties -



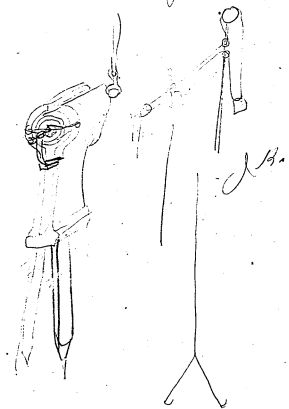
Commutator Edges
Feb. 14 1870


N





Feb. 16th 1847



6 .7782
16 1.2041
6. $\bar{1}.5742$

.3752

.33 $\bar{1}.5185$ .165 $\bar{1}.2175$
.33 $\bar{1}.5185$ .165 $\bar{1}.2175$
2. 0.3010 .3010
3.14 0.4971 .4971
$\bar{1}.8331$ $\bar{1}.2331$ 198

.171 194
.217
.388

.21 $\bar{1}.3222$
.33 $\bar{1}.5185$
3.14 0.4971
$\bar{1}.3378$

27 .135 $\bar{1}.1303$
.135 $\bar{1}.1303$
.3010
.4971
$\bar{1}.0587$

$\bar{1}.5185$ ~~$\bar{1}.1303$~~
$\bar{1}.5185$ ~~$\bar{1}.1303$~~
~~.4971~~ ~~.4971~~
$\bar{1}.5241$ ~~$\bar{2}.7577$~~

.115
.334
.449

.39 D
.24

.39 3
2

.39
.39
2.
3.14

.39 .185 $\bar{1}.2672$
.39 .185 $\bar{1}.2672$
Comp 2. 2. 0.3010
3.14 3.14 0.4971
$\bar{1}.3325$

.215
.294
.509

~~.12~~ $\bar{1}.0792$
~~.12~~ ~~$\bar{1}.0792$~~
~~.24~~ ~~$\bar{1}.3802$~~
~~3.14~~ ~~0.4971~~
~~$\bar{2}.0357$~~

.24 $\bar{1}.3802$
.39 $\bar{1}.5911$
3.14 .4971
$\bar{1}.4684$

30

.15	$\bar{1}.1761$	
.15	$\bar{1}.1761$	
2.	7981	
3.1415		
	$\bar{1}.1503$	

.30	$\bar{1}.4771$	
.30	$\bar{1}.4771$	
3.14	4971	.142
	$\bar{1}.4513$	

.285	.1425	$\bar{1}.1538$
	.1425	$\bar{1}.1538$
		.7981
		$\bar{1}.1057$

.1285	$\bar{1}.4548$	.127
.1285	$\bar{1}.4548$	.257
3.14	.4971	
	$\bar{1}.4107$	.384

February 22 1879.

Pages 73 to 91. "Use of Platinum & Iron Wires
Pyro-insulated, etc.
were wound on Pine, with Platinum for the last

Edison Laboratory Note Book # 22.

Pages 73 to 91.

See Edison Patents
227,227
227,228
213,336
214,336
214,337

should be incandescent. I effect this by using an iron wire slightly larger than the platinum, made some tests with iron and platinum wire joined together & placed between

30 .15 7.1761
.15 .1761
2. 7981
3.1415

= .1507

.30 1.7711
3.14 .4971 .142

7.4107

February 22 1879.

Conceived the idea of using a 6066in of iron wire wound on lime, with platinum for the last layer. The iron and platinum to be pyro-insulated by acetate of magnesia. and the size and resistance of the iron made so that when it was at a bright yellow approaching white that the platinum should be incandescent. I effect this by using an iron wire slightly larger than the platinum,

made some tests with iron and platinum wire joined together + placed between

supported and heated with the battery?

I find not the slightest difficulty in so selecting the size of the wires that the Pt shall be brilliantly incandescent while the iron is yellow — Hence I can make a lamp with a mch of incandescent surface (Pt) with a large resistance, the iron wire of non fusing all of its heat through the platina, thus is a gain in economy of plant.

I noticed the jerk in the contraction and expansion of the iron wire when it reached certain temperature. It is very noticeable and strong. Their expansion is different from the contraction

If but a slight strain is put on
the wire when red it permanently
Elongates with ease, I think
Electricity passing through the
wire in conjunction with this
loss of Elongation has something
to do with the [illegible]
I also noticed two sudden expansions
while the wire was cooling!
very striking when it reached a
dull red the other after the wire
was invisible, These jerks are
sometimes so sudden that
the wire is set vibrating

Covering iron with cobalt acetate & fusing again raises its fusing point in air ~~by~~ probably by preventing oxidation.

Feb 22 1879

Feb 22 1879

Experiments for Covering Wires

Battery 13 cells Bunsen
Iron, Platina 20/ Zinc ·01

With Solution of Acetate of Magnesia
and the wire made incandescent
and frequently dipped in solution.
½ inch in length when dipped
in solution does not become
red
even ¼ inch in length does not
become red
With an iron wire ·01
it does not give visible signs
of heat.

over

There is no signs of any deposit of Magnesia on these wires after dipping —

·014 Iron wire
·010 Platinum Iridium 20%

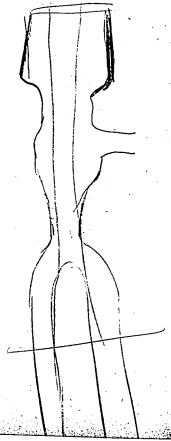
Platinum becomes bright yellow and the iron bdsely visible red. I now increase the battery keeping equal lengths of the metals in circuit
Pt becomes yellow white &
Fe becomes dull yellow.
I now increase strength of battery again
Pt becomes pale white with tinge of yellow
Fe becomes yellow —

With
Pt/Pt. ·010 20/0
Fe ·016
equal lengths.
After the oxide has become melted and run in globules along the iron, it becomes more infusible, probably because this ~~oxide~~ prevents further oxidisation, then the iron gauged after scraping off the oxide ·014

Platinum Brilliant white
Iron Yellow (dull)

With
Iridio Pt. 20/0 ·010
Iron ·011
equal lengths the iron was brighter than the Platina and melted when the platina was only yellow
This guaged after taking out & oxide scraped off.
$9\frac{3}{4}$ thousandths

With Iridio Pt 20/0 ·010
Iron wire ·012
Iron has most resistance



With equal lengths
Indio Platinum 20/. ·010
Iron ·014
Iron melted by oxidising
undoubtedly in a vacuum
this would be all right
There is the difference between
~~[illegible]~~ brilliant white and
yellow

~~[illegible]~~ Taking ·011 wire (iron) 1 inch long spiral wound close and afterwards pulled out measures 28 inches

Taking ·014 wire it measures 24

Spool made of ·014 in layers measures 15 × 10½ inches

Spool made of ·011 inch measures 26 - 9

600 m m of ·011 iron wire measures ·97 ohms

600 m m of ·014 iron wire — ·67 ohms 67

600 m.m. of Flat Indian ·010 20/ 3·93 ohms

'97 ohms = 2·81

13 ÷ 4

291

972

12·85 ohms.

97

17·3

56 inches Platinum wire

24 inch = 3·93

3·93

6·5

12 | 1·123·00 8·84

9

9

11 6/12

12

152

53

14·45

113

3

116

2

812

232

3·9 | 33 1 3 2

1·96

4

7·84

2

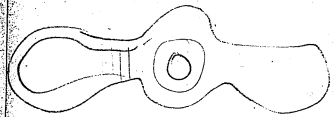
8

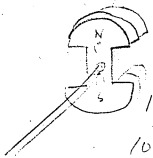
9

72

12

85





$10^2 \times 10^3 = 10^5$

$10^{2.156} \times 10^{1.242}$

250

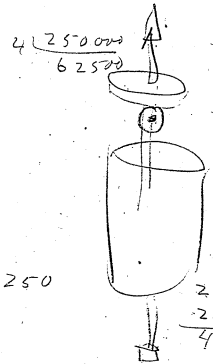
$10^{2.3979}$

10^2 100

10^3 1000

1

84



4 | 250.000
62500

250
250

250

2.3979
2.3979
4.7958

62770.

.7958

.625

.62490

722	2.85585
638	2.8014
249	2.3962
3.1415	0.4935
	8.5496

35440000.

Determination of the increase of resistance under heat of Iron wires

600 mm of ·011 iron

9 cells Heated dull red diffce 75 4.97 ohm

9 cells " red — 597

~~12 cells~~ about 4 inches was not as red as the rest

13 cells still red 6.6

15
100
900

165

·24 | 11

24 | 2·64
24
24

'011 Iron wire

300 m m Resist

6 cells dull red
7 cells red
8 cells Bright red 3·9
Resistance 3·9 ohm

9 cells Full red
10 cells yellowish red
Resistance 4·6 ohms

on again

10 cells
11 cells Reddish yellow — 5·00
12 cells Yellow with tinge of red 5·00
13 cells Yellow — 5·8 ohms

150 m m ·011 Iron wire

3 cells

6 Cells Yellow

7 cells Bright yellow

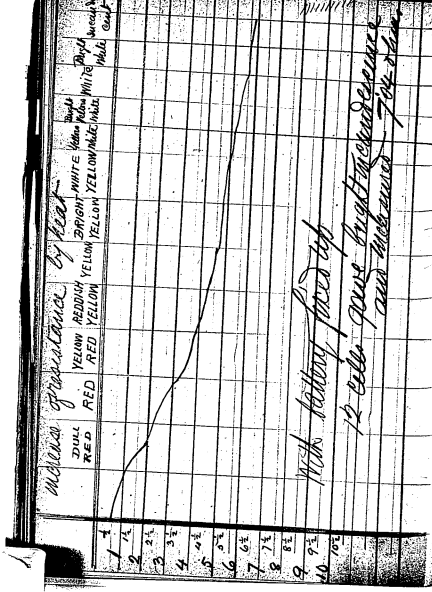
2·64 ohms

$\frac{1}{50}$

20 60 66/1000 166 166 60 9960

$\frac{3}{5}$/150 16·6

18/299·4 16·6 3



Iron wire Feb 22 1904 Charles Adler

A Spiral coil of .011 iron wire 3/4 inch long and measuring when drawn out 12 inches has ~~with~~ a resistance of .5 ohms

Now we put in a Vacuum

2 cells Dull Red — 2.2 ohms
3 cells Red — 3.16 ohms
4 cells Yellowish Red 3.8 ohms
5 cells Reddish Yellow 4.3 ohms
6 cells Yellow 4.5.7 ohms
7 cells Bright Yellow 4.77 ohms
8 cells Whitish Yellow 5 ohms
9 cells Yellowish White 5.06
10 cells Yellowish White 5.23
11 cells White 5.5
12 cells Bright White — 5.6
13 cells incandescent 6.4

9 | 2.77 / 8

11

5.54

Iron wire .011 Spiral wound
with 6 inches of wire in Vacuo

6 cells makes White 2.77 ohms
Busted at the next cell
Clear bright white

thus increasing its resistance
a little over 11 times

Feb 23 1879
Chas Batchelor

.41 / 71.4 = .475

475. .41 Cromo 71.4

2.6767
1.6128
8.1463 −10
10.4358

.4358

273

5.7 / 71.4 = 85.9

41

1.5551
0.7559
8.1463 −10
10.4573

287

11.4 19.4 71.4

1.0569
1.2878
8.1463 − 10
.4910

3.01
2.73
2.87

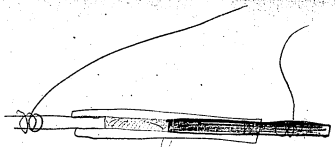
3 | 8.61
287

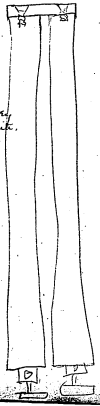
Iron wire .011 6 inch long wound in spiral and covered while hot with Acetate of Magnesia, in vacuum

Melted with 9 cells at a brilliant incandescence and before melting it measured 4.79 ohms thus increasing from ordinary temperature a little over 19 times its ordinary resistance

Feb 23 1919

Chas Latchford





Copper hard soft.
Copper soft Iron soft.
Copper hard Iron soft
Copper soft Iron hard
Copper soft Cast iron grey
" " white.
" Steel soft
" Steel hard
" Zinc sheet
" Zinc cast
"

Iron wire .015. 12 inch long
wound in spiral on $\frac{1}{8}$ mandril
covered with Acetate Magnesia
and put in Vacuo.
Resistance when cold .24 ohms.
With 12 cells it gave about
3 candles and melted at
brilliant white

Feb 29 1879

Chas Batchelor

1 Weber = current that
1 Volt will send through 1 Ohm

12

6 Ohms

6 Ohm

12

24 = E

$C = \frac{24}{12} = 2$

12 Ohms

2 Weber

24 Units

$C^2 R t$

2 E

10^{-1} 10^{+8} =

10^7 Works

1 Weber Wr

10 000 000

10 000 000

10,000,000.

10 000 000

10 000 000

10 000 000

Gramme Centimeter

~~10,000,000~~

~~10000 000~~

~~10000000~~

~~10,000 0000~~

10^{-1}

$\frac{1}{10} \times \frac{1}{10} = \frac{1}{10^2}$ $10^9 = 10^7$

~~10,000,000~~

~~1000000~~ $\frac{2^2 m}{T^2}$ Kilo

100

~~1000~~ 10 Kilo Metres

1000

24000

100

$\frac{3}{2}$

1000

1000 Gm. Mt. 43380

1 Gm. Mt. 4 (433.80.

10,845

1 Gm. Mt. 6

.002205

3.281

.0072339

7.2339

7.25

60

433.80

A ~~a~~ absolute unit Gm. M. S.
is equal to how many Gm. M.

$\frac{1}{981}$ Gm Cm S

~~Gm C Cm~~

A Dyne is equal to the
Wt of $\frac{1}{981}$ Grammes at Paris

Gm ~~Cm S~~

Gm. Cm S. $\frac{1}{981}$ Gm Cm

$\frac{1}{981}$. $\frac{1}{981}$ $\frac{1}{981}$ $\frac{1}{981}$

$\frac{L^2 m}{T^2}$ $\frac{1}{981}$

$\frac{10000}{981}$ $\frac{100}{981}$

.0010195

100. 2
981. 2.991669
$\bar{1}.008331$

.1019 42

Gm Cm S = Dyne

$\frac{1}{981}$ Gm Cm = Eng

33000 ft. lbs. Eng

$\frac{L^2 M}{T^2}$ 33000
33.000
33.000

$\frac{L^2 m}{T^2}$ = G

$F = \frac{mv}{t}$ $\frac{Lm}{T^2}$

33000

33000 ft. lbs

39000

$$lb = \left(\frac{l^2 m}{g^2}\right)$$

$$ft = \frac{}{l}$$

Kilo $\frac{1}{981}$ cwt

16 ft

$lb = 16$ ft

33000 ft lbs

$$ft = \frac{1}{3.28089} \text{ Metres}$$

lb

Gramme metre =

$\bar{3}.859372$

12.140628

2.140628

$4 \overline{)4200}$

1050

138.2

$\frac{3}{500}$

log 33000 4.518514

$\bar{1}.140628$

3.659142

4562. Kilo Metre = H.P.

456200 Kilo. Cm.

456,200,000 Gramme Cm.

456,200,000 X 981 = Gr. Gm S

= Ergs

~~A = 63°~~

A = 63°

55° 30'

R = .4 .5

1.96

1.45

.51

.5 $\frac{.5}{1.45}$ 1.50 $\frac{.5}{63.}$ $\frac{5}{3}$

1.5

.5 $\frac{5}{14}$ $\frac{2.5}{14}$

14)2.5 (.17

14

110

98

12 .18

.41 X .51

1.45

41

205

1.45)2.091 (.14

145

1.641

680

.14 Ohm

~~87°~~ 30' 4.51

70° 30' 2.82

.6 Ohm

4.51
2.82
1.69

2.82) 8.45 (3
.15
846

.1.5 Ohms

30
6
2) 22

.11 Ohm

12 12
121
132

12
132

12
1.32

24
1-32

24
42
48
196
2008) 33000 (15

24
2

12
12
144

Bright red 14 Ohms

300 mm 10% Pt Ir .005 in

---

600 mm cold

17.5 9 ques

8.7

---

200 mm 10% .005

10 Ohms

Bright yellow

---

150 mm White 8.7 Ohms

Cold 4.2 +

4 | 17.5

4.37

125 mm Very white .98

Hot 8 Ohms; Cold 3.4 Ohm

---

100 mm Melted

Lamps cold ~~3.6~~ Ohms

3.6

.60

Say lamp 10 ohms hot

~~[illegible]~~

~~[illegible]~~ 15 internal

2.5 ~~[illegible]~~

$\frac{24}{2.5} = 10.$ Webers

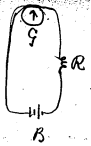
~~[illegible]~~ 25

42 ft lbs Weber Ohm minute

420 ft lbs

$$42\cancel{0}\,)\,33000\,(78$$
$$294$$
$$360$$

$C^2 R$



D = Deflection

$$D = \frac{\mathcal{E}}{G + R + B}$$

$$\frac{1}{R_T} = \frac{1}{S} + \frac{1}{R_1 + G}$$

$$\frac{1}{R_T} = \frac{R_1 + S}{R_1 S} \qquad R_T = \frac{R_1 S}{R_1 + S}$$

$$C = \frac{\mathcal{E}}{\frac{R_1 S}{R_1 + S}}$$

$$D : C :: \frac{R_1 \mathcal{E}}{R_1 + S} : R_1$$

$$D = \frac{\mathcal{E}}{R_1 + S} C$$

$$D = \frac{\frac{\mathcal{E}(R_1 + G)}{R_1 + G}}{\frac{S}{R_1 + S}} = \frac{\mathcal{E}}{R_1 + G} = \frac{\mathcal{E}}{G_-}$$

$$\frac{1}{R_T} = \frac{1}{S} + \frac{1}{R_1 + G} = \frac{R_1 + G + S}{S(R_1 + G)}$$

$$R_T = \frac{S(R_1 + G)}{R_1 + G + S}$$

$$C = \frac{\mathcal{E}}{\frac{S(R_1 + G)}{R_1 + G + S} + B}$$

$$D : C :: \frac{S(R_1 + G)}{R_1 + G + S} : R_1 + G$$

$$D = \frac{S}{R_1 + G + S} \times \frac{\mathcal{E}(R_1 + G + S)}{S(R_1 + G) + B(R_1 + G + S)}$$

$$= \frac{\mathcal{E} S}{S(R_1 + G) + B(R_1 + G + S)} = \frac{\mathcal{E}}{G + R + B}$$

$$S(R + R + B) = S(R_1 + R) + B(R_1 + G + R)$$

$$SR - SR_1 = B(R_1 + G)$$

$$B = S\frac{R - R_1}{R_1 + G} \quad \text{Ans.}$$

$$D = \frac{\mathcal{E}}{\mathcal{G} + R + B}$$

$$D_1 = \frac{\mathcal{E}\, S}{S(R + \mathcal{G}) + B(R_0 + \mathcal{G} + S)}$$

$$S D (\mathcal{G} + R + B) = D_1 (S(R + \mathcal{G}) + B(R + \mathcal{G} + S))$$

$$S D B = D_1 S + D_1 B + D_1 \frac{B S}{R + \mathcal{G}}$$

$$B = \frac{D_1 S}{S D - D_1 - \frac{D_1 S}{R + \mathcal{G}}}$$

$$S \frac{D_1}{S D - D_1 - \frac{D_1 S}{\mathcal{G}}} \qquad R = 0$$

$$S \frac{D_1}{S}$$

$$\frac{D_1}{S D - D_1 \frac{\mathcal{G} + S}{\mathcal{G}}}$$

$$D = \frac{\mathcal{E}}{\mathcal{G} + B}$$

$$D_1 = \frac{\mathcal{E}\, S}{S \mathcal{G} + B(\mathcal{G} + S)}$$

$$S D (\mathcal{G} + B) = D_1 S \mathcal{G} + D_1 B (\mathcal{G} + S)$$

$$S D B - D_1 B (\mathcal{G} + S) = D_1 S \mathcal{G} - D S \mathcal{G}$$

$$= (D_1 - D) S \mathcal{G}$$

$$B = \frac{(D_1 - D) S \mathcal{G}}{D S - D_1 (\mathcal{G} + S)}$$

$$= S \frac{(D_1 - D) \mathcal{G}}{D S - D_1 (\mathcal{G} + S)}$$

$$\frac{(D - D_1) \mathcal{G}}{D_1 (\mathcal{G} + S) - D S}$$

$$B = \frac{D - D_1}{D_1 - (D_0 - D) \frac{S}{\mathcal{G}}} = \frac{D - D_1}{D_1 \frac{\mathcal{G} + S}{\mathcal{G}} - D \frac{S}{\mathcal{G}}}$$

1.030

60° 30

52°

.2 Ohm

1.76
.27
.49

.49
1.27

.49
.2
1.27) .9.80 (.0

.49
.2
.098

1.27) .09800 (.08 49

470 1.07

.1

2.70 .50

1.07
.50
.57

.50) .057 (.11
50
70

.11 Ohm

Condit I Hanscome Old

Used a thick wire of Ohm for resistance under formula

$$B = S\frac{D - D_1}{D_1}$$

N = 49° 30'

31°

60) 0.57
.096 Ohm

1.17
.60
.57 another cell

.60) 0.47
.08 Ohm

No 3 cell

58°

35°

1.60
.70
.90

.70) .90 (
.13 Ohm

50°

280

1.19
.53
.66

53) 066 (.12
53
130

.11
.12
.13
.09
4) .45
.11

New cell

Chromate new

50°

26°

1.19
.48
71

48) .071 (.15
48
230
240

Meen outside

450

21 30

.16 Ohm

1.00
.39
61

39) .061 (.15
39
220
195

Battery old 13 cells

11
13
33
11
1.43 Ohm

Fresh .15
13
45
15
1.95 Ohms

3) 26
8.66

$\frac{26}{3}$ = Weber

$\mathcal{E}$ = 26 Volts

R = 3 ohms

8.66
8.66

0.937518
1.875036

3316) 33000 (10
3316
75.

.737
60
44.220
75.
221.10
30954
3316.50

1.0 lamps per H.P.

Metre = 3.281

7.2331 ft lb. = 1 kilo Meter

log = 0.8593

.13825 kilo Meter = 1 ft lb

log = 9.1407 − 10.

Erg = .00102 Gr. Centi.

Erg =

1 Gr. Centi. Sec. = $\frac{1}{981}$ Gr. centi = log

log .00102

log = 7.009 − 10

1 Kilo Meter = 1000 × 100. Gramme Centi

= 10^5 100000

= 10^5

1 Weber = 10^{-1}

1 Ohm = 10^9

$\frac{1}{10}$

$(10^{-1})^2 \times 10^9 = 10^7$

log 10^7 7.

Comp log .13825	.8593	
comp log 10^5	5	−10
log .00102	7.009	−10
	$\bar{1}.8683$	

.738

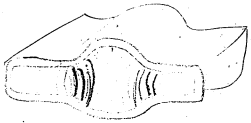
60

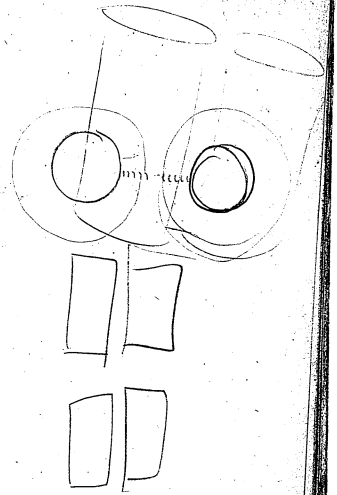
44.280 ft lbs Weber over one Ohm

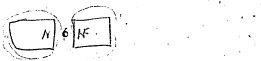
1.21	0.0828
1.82	0.2601
1.16	0.0414
	.3843

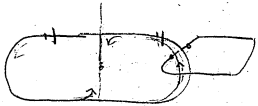
2.4

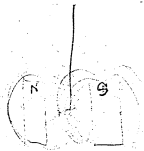
3.14

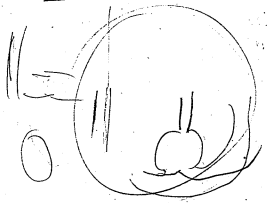


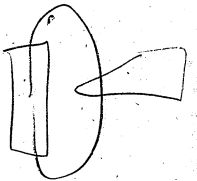



N
6
N




N
S





$\frac{1}{981}$

1.033 tile

= 1033. Grammes

1033
980
82640
9297
10.12340

1.32

33000 1 Ohm

1 Ohm C = 1 Ohm
1 Volt
1 Ohm 1 Ohm
1 Ohm 1 Ohm Ohm
1 Ohm 1 Ohm
1 Ohm 1 Ohm 1 Ohm
1 Ohm 1 Ohm

772

~~1 foot~~

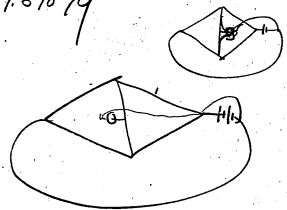
772 foot lbs.

1 foot lb =

1 lb -

1 foot = 13.37079

$= \frac{12}{39.37079}$ metre



$C = \frac{E}{R}$

$C = \frac{L^{\frac{1}{2}} m^{\frac{1}{2}}}{T}$ $\quad R = \frac{L}{T}$

$C^2 R^2 = \frac{L^2 m}{T^3}$

$\frac{L^{\frac{3}{2}} m^{\frac{1}{2}}}{T^2} \quad \frac{L^3 m}{T^4} \quad \frac{T}{L}$

$\frac{L^2 m}{T^3}$

$$C = \frac{\mathcal{E}}{R}$$

$$\frac{\mathcal{L}^{\frac{1}{2}} m^{\frac{1}{2}}}{J}$$

$$\mathcal{E} \quad \mathcal{E} \quad \mathcal{E}$$

$$C^2 R = \frac{\mathcal{E}^2}{R}$$

$$C = \frac{\mathcal{E}}{R}$$

$$W = \frac{\mathcal{L}^2 m}{J^2}$$

Ahrw. do gmcks

$$C^2 R t$$

$$C = \frac{\mathcal{L}^{\frac{1}{2}} m^{\frac{1}{2}}}{J}$$

$$R = \frac{\mathcal{L}}{J}$$

$$C^2 R t = \frac{\mathcal{L}^2 m}{J^2}$$

$$W = \frac{\mathcal{L}^2 m}{J^2}$$

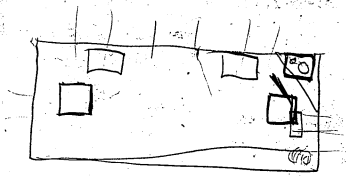
foot-lbs $\frac{\mathcal{L}^2 m}{J^2}$

foot $\mathcal{L}$

lb $\frac{\mathcal{L} m}{J^2}$

force $f = \frac{m}{J}$

$$\frac{\mathcal{L} m}{J^2}$$



500 Ohm lamps

Weber² Resistance

3300 for 15 candles

$C^2R = 3300$

$C^2 = \frac{3300}{500} = 6.6$

$\frac{26}{3} = 8.66$ Webers

8.66 Webers in 10 hm lamps to bring it to 1 mcw — descence

$(8.66)^2 = 75$

75 Units watts given off by 8.66 Webers in 10 hm

How many Webers will be required to give off the same on 500 Ohms

$\frac{75}{500} = .15$

$\sqrt{.15}$ $\bar{1}.1761$

$\bar{1}.5880$

by .387 Webers

$.387 = \frac{x}{500}$

$.387 \times 500 = 193.500$

193 Volts

$26)193$
182
110

$866)193.500\ (22$
1732
2030
1732
0

9900) 33000 (33
297
330
297

3.3 3 Batteries to ~~give~~ give out in all 1 HP of on a circuit with 1 Ohm outside. 3.6 = E R+r = 3 Ohm

13 cells C.H.H

26 Volts

9900 ft lb of energy given off every minute

1 lb of Zn has

33 grms Zn gave off — burning in H_2SO_4 18682 Grmm C°

log 18,682. 4.261377

log 4.2 Gm Molecs 2.627366

log Kilo M. 7.233 0.859318

Comp Hong 33. 8.481486 − 10

1.5185 14

Grm Cent = 424 Kilo M 6.229547 − 10

3

3

1,698 ft lbs for gm

English

4 5

5 | 38 25

7 6 5

1772

5

9 | 3866

427

150 9/5 5/9

100

English

Ely

Remember ft lbs

42 @ Gm Water = 1 Gm H_2O 1°C

How many ft. lbs. = 1 lb 1°F

log 424

log $\frac{9}{5}$ = 1.8

log

9900

60

594,000) 1,848,195.

log 1.848 ~~000~~ 6.266747

226214

amp log 5.94,000 ~~4.773946~~ -10

.492961

3.11 hours to burn one lb of Zn in 13 cells on one Ohm outside these being no polarization and the whole equiv. used of the Zn. No local action ✓.

$$\begin{array}{r} 772 \\ 9 \\ \hline 6948 \end{array}$$

$$\frac{9}{5} \times \frac{1}{3.28}$$

$$\begin{array}{r} 5 \\ \hline 16.40 \end{array}$$

$$16.4 \overline{)6948} \; 424$$

$$\begin{array}{r} 656 \\ \hline 388 \\ 328 \\ \hline 600 \end{array}$$

772 ft lb = 1 lb 1° F

$772 \frac{9}{5} \times \frac{1}{3.28}$ gr Metr 1 gr 1°C

= 424

What does 1/2 in. Cu wire weigh lb. per foot and cost

1/2 Sp. G. Cu = 8.9

18 cts per lb.

$A = \pi R^2$

$R = \frac{1}{4}$

$R^2 = \frac{1}{16}$

Area, circle	log	3.1415	0.4970686
Area sq.	log	16	8.7958800 -10
length	log	12	1.0791812
sp. Gr	log	8.9	0.9493900
cost	log	18	1.2552273
grains in cu. in. water	log	252.4	2.4020899
grains Cu.	log	7000	6.8450980 -10
Cost foot			1.
Cost cu. in			
Cu. in in ft of wire			

log 1323.5 3.121560
Comp log 7000 6.154902 -10
log 18 1.255273
log 4 .602060
1.133795

@ 13.8 cts per ft

.189
4
.756

7/4 lb. per ft ½ in wire

7000 | 1323.
189
4
.756

189
1000
.756
18
6048
756
13.60

252.5 2.402261
comp 64 8.193820 -10 1/4
3.1415 0.497068 1/8
12 1.079181
2 wi 1.72330
8.9 0.949390
3.121920

1/4

1324. Grains in ft

13.8 cts per ft

4 | 1654
.0413 Ohms in 1000 ft ½ in
528
3304
826
2065
.218066 Ohms in mile
25
1090
436
.5450 Ohm in 2½ miles

6 / .5450
.0908

6 strands 1/2 in
thus 2 1/2 mile

.0605 / 500000. (8223.
4864
1360
1216
1440
1216
2240

1 : 8223
1 : 8000

15 / 500 (33
45
55

~~.0608~~

.0608

.0908
.0908
.0908 in Machine 500 : 1
say

$200 a year interest 10
each lamp but 3 hours a day
say 1000 hours a year
30000 hours in all

~~3000 / 2000 cts~~
.666+ cts
$.00666+ an hour for interest
at a distance of 2 1/2 miles

35.1
10.2
2.51

Tragic on E. M. F.

Calory = 423.55 Gramme Metre

a calory is the amt. of heat required to bring 1 Gram of H_2O from 4°C to 5°C

1 Gramme of H gives out 1330. Calories in burning

H 6800 ft. lb. per gram equiv. ~~H~~

~~47600000~~ 7000 ft. lb. in lb.

6) 47,600,000
7,950,000

4) 47,600,000
11,900,000

10
32.6) 47,600,000 (1,466,000
32.6
1500
1304
1960

A Current that uses 32.6 grains of Zn in battery will carry 108 grains of Ag in Voltametre or 1 grain of H free or 8 grains of O

That is any current will

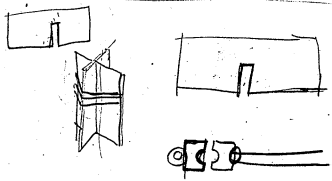
1000 103

108) 01.116 (.0001
0108

.00552
2
.01104

.0106 .00186
2

C.S.S
.00092



8

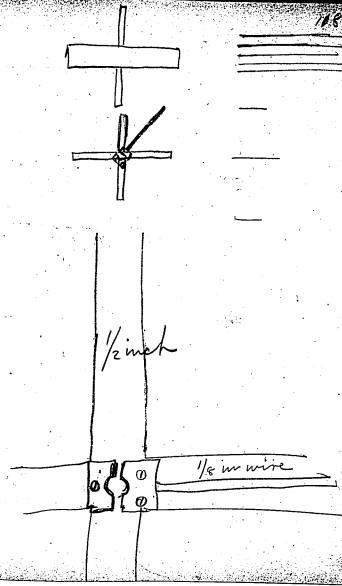
4 inch

? ft

4 inches wide

12 high

notches 1/8 inch apart



425 Gramme Metre

42500 Gram Centimetre

42500	4.628389
981	2.991669
	7.620058

Calory = 41.700.000 Absolute measure
Gm. Centi. S.

$qq = Qq\,\theta\varepsilon$

$q = J\,\theta\varepsilon$

$qq = qq\,\theta\varepsilon$

	Jenkin	Emy. Brit.
$\varepsilon =$ Zn	.00342	.00336
Cu	.00324	.00326

324	2.510545
342	2.534026
	1.976519

.954	
326	2.513218
336	2.526339
	1.986879

910

788.9 = Thermal equiv 1 Gramme Zn in Daniells cell

Smee

33 | 18682 (566.
165
218
198
202
198

Daniells

65 | 47470 (736
453
237
195
420

34.462 Grammes of H_2O raised from 4°C to 5°C by the combustion of 1 Gramme of H

1 Gramme H_2O raised from 4°C to 5°C is equal to 4235.55 G.C. = 1 Calory
423.555 G.M

1 lb for gram 34.462
.198547
7000
51.320000

4.567320
7.297778
4.845094
8.710216

34.462 lb from 4°C to 5°C
1 lb. H

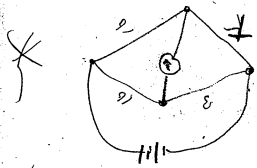
34.462
9
5
.18

34.462 34.462
34.462 34.462 34.462

34.462 4.567320
1.8 0.255273 Right
7.2 2887617
3.28 51.5574 Metric do not
8.226084 come into the calculation
.2 .510546 Wrong
7.0 1538

~~51.470000~~. If the Wrong
as p. before
47.890.000 ft lb
~~Raise from~~ It takes 5/9 of the energy to raise 1 lb of H_2O from 37°7 to 38°7 than it does the same from 4°C to 5°C

9/5 more lbs. can be raised from 37°7 to 38°7 than from 4°C + to 5°C by the same amt. of heat.

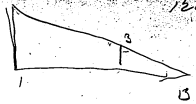


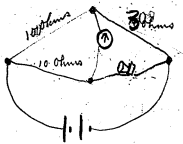
Lamps	hours	at under month
100.	10	
200	20	1
300	30	2
400	40	3
500	50	4
600	60.	5
		6

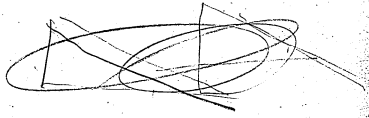
10 (300000

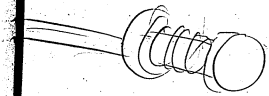
30 3000 lamps per month

100. lamps a day









7.0082849
2.6269.47
4.3813802

7.0082849
3.8593
4.8675

Calories per gramme means the no. of calories a gramme of any substance will give in burning.

1.1884
2.6269
3.8593
1.6746
2.3768
7.2978

To change Calories per gramme to calories per gram divide by $\frac{1}{15.434}$

2 ohm

13

26

4.2
13

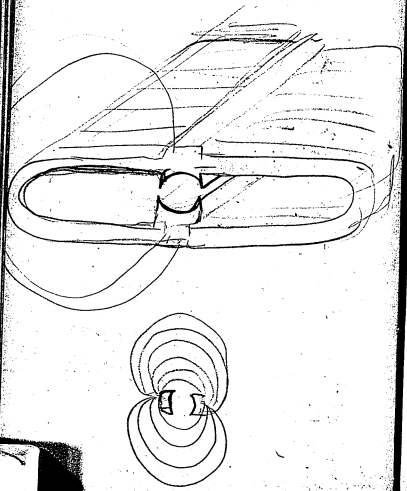
90 ft

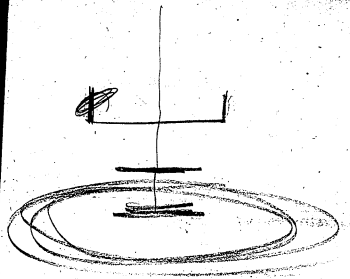
4.2
2
8.4

98 | 3304
3.85

13
13
0

1.3813859





.10192	$\bar{1}.008284$
1000.	3.
.0072339	$\bar{3}.859372$
60	1.778151
	1.645807

44.24

ft lbs per unit of current through a Ohm work done in a minute

1 Weber of current will ~~free~~ decompose .00093 Grammes of H_2O in one second or .000103 Grammes of H will be given off at the pole. That is one Faraid passing through a ~~[illegible]~~ H_2O will decompose this amt.

.00093 Grammes equals how many grains

log .00093	$\bar{4}.968683$
log 15.4	1.188478
	$\bar{3}.156961$

.01435 Grains of H_2O in one second

This is what Sprague calls a Chemic M

in a 10 hours.

36000

A chemic is the amount of current wh. is required to free 1 grain of H in ten hours.

A chemic is a current of such strength that it will decompose 1 grain of H in ten hours. So he say but his table makes it only one hour

.0142	.00142	
14.	1.42	1.42
	36	36
	852	51.12
	426	
	51.12	

Brit. Encyc. p. 105

says that a Weber & see before

.00093 Grammes in one second

7000 Grains

1 Kilo = 2.205 lbs

$\frac{1}{2.205}$ Kilo = 1 lb

= 7000 grains

$\frac{1000}{2.205}$ Grammes = 7000 grains

$\frac{1}{2.205}$ Gramme = 7 grains

~~2.205) 7000 (3~~

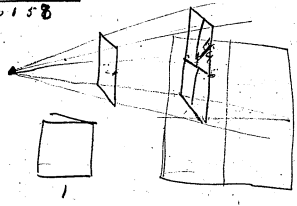
1 Gramme = 15.435 Grains

.00093
15
465
93
.01395

93

		20 +
20	-5	35 −

9/0142 −5
.00158



1 Weber through 1 ohm

44.24 ft. lbs. in minute

log 1.645807

~~C.G.S. lbs~~

1 Weber through 1 ohm

give 100,000 C.G.S. units of work

~~log 100000~~ 5

log .0010192 $\bar{3}.008284$

antilog 423.55 ~~2.626455~~

7.373145

$\bar{4}.381429$

.2406

.2406 Calories for 1 Weber during one second.

1 Weber in one hour will burn use 5.68 grains of H

I don't know what he means

Sprague p. 216 shows that the equiv. of 1 grain of H will give 4673 ft lbs of energy ~~in a hour~~

4673

70000

32,731,000 ft lbs in lb of H!

.000163 $\bar{4}.012837$

15.435 1.188566

$\bar{3}.201203$

log .001586 log $\bar{1}$ = 0

2.798797

629.2 Seconds for one Weber current to ~~decompose~~ put hydr. 1 grain of H from H_2O

$\frac{1.37}{86}$

.00158 $\overline{3}$ 201203

3600 3.

1 Web of current will set free .000103 Grammes of H in one second.

The electromotive force depends on the energy given off by atomic equivalents ~~[illegible]~~ ~~[illegible]~~ when all the energy of combination is changed to electricity.

.000103 Gramme

.00103 Deka Gramme

.0103 Centigrammes

.103 Milligramme

200 ft. lb.

6.
45

5.00

12.
12
144

65) 47170 (733
35 5
267
195
220

733 Heat units for Grammes of Zn. in Daniells Rawlett

1 Weber of current requires .03411 Grammes of Zn every second to be carried into solution. Brit. Cyc.

P. 84

From deg C

733 - Heat units.

log	733	2.865104
log	~~42355.~~ 42355.	4.626340
log	.03411	$\bar{1}.532882$ $\bar{5}.150891$
log	9.81	0.991669 1.415550
		18.015995

~~Ida~~ Volts

1 Daniells = 1.037×10^8 ans

42355 Gm C = 1 Heat unit Brand

~~1~~ 1 Gm C = 9.81 C.G.S.

Decimal gives

the Gramme of H burning will heat 34.462 Grammes from 4° 4.50

it will form 9 Gramme of H_2O

so 9)34462

3829 Heat units in one gramme of H_2O

Zn	733	2.865104
	32.6	1.513218
		4.378322
comp		5.621678 −10
log 34.462		4.537318
		10.158996 −10
		0. +

log. 1.442 the electromotive force of H_2O in ~~Volt~~ Daniells when decomposed i.e the lowest E.M.F that will send a current through H_2O

How many ft lbs of Zn will it require in a Smee battery to produce a H.P in heating of whole circuit Ans Every 1.85

Data 617 Thermal units from burning 1 unit of Zn — Gm Degree C

log 617	2.790285	
log 141550	5.150891	
	7.941176	

.873 Volts = E.M.F.

1 Thermal unit Gm Degree C. = 141550 F.C.S
log = 5.150891

9/5 = 1.8

9/5 617 Thermal Gm Degree C = X Thermals Eng

617	2.790285	
1.8	0.255273	2.142890
772	2.887617	
	5.933175	

857.350 ft. lbs.

log 857.350	5.933175	
comp log 33000	5.481486	− 10
	1.414661	

25.95 H.P. for one minute by the burning 1 lb of Zn. in a Smee battery.

How many lbs of Zn. to run 1 H.P. one hour?

log 60	1.778151	
comp log 25.95	8.585339	− 10
	.363490	

2.31 lbs of Zn to ~~give~~ a H.P for one Hour from a Smee battery Zn. & Pt. in one fluid.

The same questions for Daniell's battery.

Data Brit Eng P. 85 805 Thermals

log 805 — 2.905796
log 1.41 — 5.150891
8.056687

1.14 Volts

2.905796
3.142890
6.048686
402
4

4118,700. ft lbs

from one lb. Zn burned in Daniells.

6.048686
5.481486 − 10
6200
1.520172

33.1

~~55.1 ~~

Consumption 1 lb per minute.

1.778151
8.479828 − 10
19.957979

1.44

~~9.6~~ lbs per hour per H. P.

Carbon bichromate

1.9 Daniells

1.14
1.9
1026
114
2166 Volts

1.118.700
1.9

6.048686
0.278754
6.317440

2.078000 ft. lbs. per lb. Zn.

Nitric acid

⊕ = 1,387. Heat units

7.297798 Calories per gramme
3.845098 = foot lbs per gramme X kg
3.142896 to reduce calories to foot lbs

1,387. 3.142076
3.142896
6.284972

1,927000. ft. lbs. per lb. Zn

Favre & Silbermann give a Lime as equal to 566.
i.e.: 1 Gm of Zn will heat 566 Gms. of H_2O from 4°C to 5°C

H	Thermal units
34,462.	4.537318
1.87	3.142890
772.5	
	7.680208

47,899,000 ft. lbs. by burning 1 lb. of H.

7.680208

Comp. log. 32.6 8.486782 -10

86.166990

1,468,000 ft. lbs. from 1 lb of Zn burned in O.

34462 lbs raised for

Sprague gives Zn burned in O

1 lb 1,845,000 ft. lbs.

Carbon 11,228,000 ft. lbs. per lb

1 lbs for H.P. for hours

log 11228000		7.050310
comp. log	33.000	5.481486 -10
div by	60	8.221848 -10
		.753644

$\frac{1}{5.6}$ of the theoretical

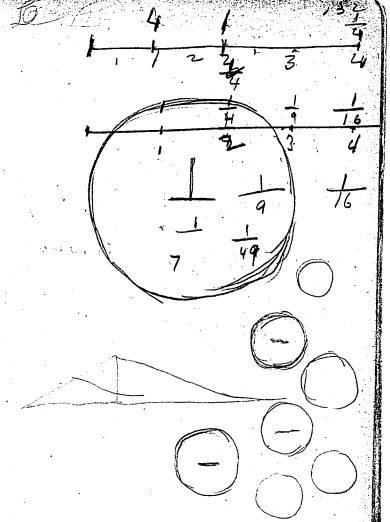
2 lbs	11.2	33000
3 lbs	168	60
4 lbs	22.4	1980,000
&c	&c	

1.845000 ft. lbs. per lb gas
burnt in air

6.265796
6.857164 −10
3.123100

1328 calories ~~[illegible]~~
1330 " Sprague

7 mo) 47,896,000.
6,833.



How many foot lbs in a megalerg = 1,000,000 ergs

981 Ergs = Gramme centimetre

1 Gramme = ~~[illegible]~~ .002204 lbs

1 Centimetre = .03281 ft.

log .002204 = $\bar{3}.343212$

log .03281 = $\bar{2}.516006$

Comp log 981 = 7.008331-10

8.709668

.00000005324

.00005082

.00007232

.0000007371

$\bar{3}.343212$

~~[illegible]~~

$\bar{5}.701337$

$\bar{3}.343212$

$\bar{2}.516006$

$\bar{3}.859218$

7.008331-10

8.867549

Megalerg Erg six

.07371 ft lbs

33000 Erg sec = 7.371 ft lbs

Erg = Gm. Cent. S.

1 Unit of work = 10^7 Weber through Ohm

= .7.371 ft lbs in one second

.7371
60

44.2260 ft. lbs. in a minute given off by a Weber a second

A Weber per second through 1 Ohm gives off 10 Megalergs of energy in a second or 1 Erg seven

Log 33000 4.518514
Complog .07371 11.140782 -10
5.659296

456.200 Megalergs ~~in Hlbs~~ at H. P
456.2 Erg nine

To raise 1 Mgr from the earth a force of 9806 $\frac{Mm \cdot Mgr}{Sec^2}$ is required

9806

1 Grammer
980.6 $\frac{Cm \cdot Gr}{Sec^2} = F$

Lifting 1 Gr 1 Metre requires work
$9806 \times 10^6 \times \frac{Mm^2\ Mgr}{Sec^2}$

$9806 \times 10^2\ \frac{Cm^2\ Gr}{Sec^2}$

Kohlrausch gives the equiv 1 Gm H_2O 0°C to 1°C as 430 Grammo Metres

$= 430 \cdot 9806 \cdot 10^6 \cdot \frac{Mm^2\ Mgr}{Sec^2}$

423.55 Shengue
424 Richering
430 Kohlrausch

2500
$ 7500000

$R = R\frac{\Delta - \Delta_1}{\Delta_1}$ R = .55 Ohm
.15 Ohm

$\Delta = 35°$

$D = 36^\circ$ 3

$D_1 = 16^\circ$

.15

~~2.54~~
28

.649
1286

363) 649 (20
626
230

.15

286) 363 (1
286
770

.15
13
45
15
1.95 ohms

37° 45'
16°

The method of measuring resistances is very faulty as the polarization of the battery gives a lo

2 cells

$S = \frac{D - D_1}{D_1}$

$S = .15$

$D = 649$

$D_1 = 286$

$D - D_1 = 363$

Very acid fresh

286)363 (1.26
286
970
572
1980
~~1430~~
1716
264

127
.15
635
127
2 | .1905
.095 ohms

$37^\circ 45'$

16°

$\frac{D - D_1}{D_1}$

$D = 753$

D_1 286

467

286)467 (1.63
286
1810
1716
940

1.63
.15
815
163
2 | .2445
122

Resistance of Conduit and Plant

$$\begin{array}{r} .122 \\ 13 \\ \hline 366 \\ 122 \\ \hline 1.586 \end{array}$$

1.6 Ohms total
battery old

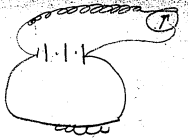
1.3 Ohms when new

$$2.3 \overline{)26} \quad \begin{array}{r} 10 \\ \hline 10 \end{array}$$

$$\begin{array}{r} 10. \\ 10. \\ \hline 100 \\ 44 \\ \hline 4400 \end{array}$$

$$4400 \overline{)33000} \; (7.5$$

$$\begin{array}{r} 30800 \\ \hline 22000 \end{array}$$



$ 35

300000

$ 270000

18000)

18000) 300000 ($16.

18

120

108

120

365

912

1.74 0.2405

10 1

365 2.2041

4446

365 2.

2.50

365500

1597

30 2.5623

$47.910. 0.1761

2.7384

.507,350 5.7050

2250 3.3522

2.35528

$ 350 0.5441

225. 2.8969

$788.

160 365 2.5623

24 1.3802

160 2.2041

6.1466

1410000 365. 2.5623

2.50 0.3979

~~2.6020~~

2.9602

2294 3.3519
480 2.6812
.6707

$\sqrt{4.68}$

365 2.5623

log $\sqrt{4.68}$ .6707
7.4377
8.1084 − 10
3.1084

.0013
.13

$\sqrt{4.68}$ .6707
3.5623
$\bar{3}$.1084

1.2 11.92

1.0762
3.5623
$\bar{3}$.5139

.0032
10
$\sqrt{11.92}$
10
$\overline{24}$ 11.94 1.0762
.3802
.6960

$\sqrt{4.93}$

54
365
50

18.250)

18.25) 4.93

.6960
1.2613
1.4347

.27

1.2613
3522
1.6135

41.10

18.250
.60
$10.96000

18000) 37800000

51.5740
41.2553
1.3187

20.80

375,000 for central state

$75,000 conductors

1 X 8 = 8
2 X 7 = 9
3 X 6 = 9
4 X 5 = 9
5 X 4 = 9
6 X 3 = 9
7 X 2 = 9
8 X 1 = 1

2
3
4
5
6
7
8
9
9

18 = 6 X 6

1000

365

274

50

$\frac{1}{18}$

8.

2.5623

.4377

1.6996

.4377

1.2613

18. of the time gas burned in day of 18 hours

$\frac{24}{140}$

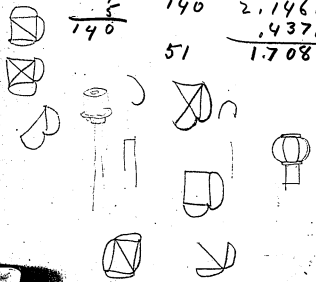
140

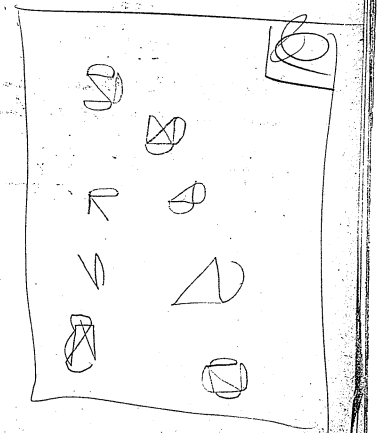
51

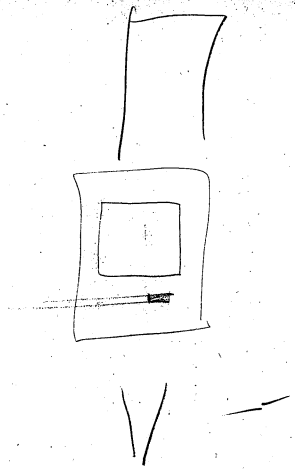
2.1461

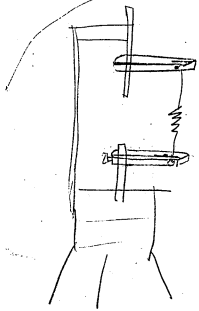
.4377

1.7084





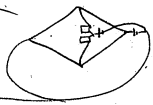


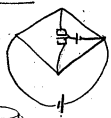


~~23356~~

Ref 10%

.362
.2552
.2739





135

15 90.

120,000

6000. 66.60

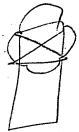
126.60.

33
20
6.60.

10.00 18000

20 36000 38 from library

7000.



22.5	1.3522	10.2	1.0086	85.1	1.9298
18.75	1.2729	17.4	1.2405	20.9	1.3201
15.	1.1761	27.39	1.4386	12.9	1.1106
12.50	1.0969	109.	2.0374	3.23	0.5092
13.75	1.1383	17.4	1.2405	18.9	1.2765
11.25	1.0511	25.82	1.4065	14.6	1.1644
9.38	0.9719	104	2.0170	3.56	0.5514
20.00	1.3010	2.87	0.4579	71.4	1.8537
10.	1.0000	19.4	1.2878	11.4	1.0569
8.75	0.9420	35.9	1.5587	5.7	0.7559
8.12	0.9096	475	2.6720	.41	1.6128

log 31.103

$1 mg = \frac{1}{31.103}$ oz Troy

= .0000321 oz

4.6	2.6710	.072	4.8594
3.9	2.5911	.061	4.7891
3.1	2.4949	.048	4.6833
3.6	2.4157	.040	4.6041
2.8	2.4571	.044	4.6433
2.34	2.3698	.036	4.5833
2.	2.3005	.030	4.4799
4.2	2.6208	.064	4.8092
2.9	2.3188	.032	4.5072
1.8	2.2608	.028	4.4492
1.6	2.2284	.026	4.4168

21.7	1.3365		
12.5	1.1053		
7.86	0.8958		
1.9	0.2944		
11.6	1.0617		
8.9	0.9498		
2.17	0.3366		
43.5	1.6389		
6.8	0.8324		
3.4	0.5311		
.25	1.3980		

.00099	4.9999	1000	3.
.0017	3.2318	588.	2.7681
.00268	3.4289	373	2.5711
.0107	2.0287	93	1.9713
.0017	3.2318	588.	2.7682
.00250	3.3978	400	2.6022
.0102	2.0083	98	1.9917
.00024	4.4492	3500	3.5508
.00198	2.7091	505	2.7209
.00355	3.5500	282	2.4500
.0046	2.6693	217	2.3337

.046	2.6695		
.078	2.8945		
.123	1.1042		
.510	1.7056		
.086	2.9383		
.113	1.0504		
.46	1.6634		
.023	2.3611		
.147	1.1679		
.294	1.4689		
5.07	.7020		

.48	1.6811	31.	1.4927
.825	1.9160	53.	1.7240
1.26	0.1007	83.5	1.9217
8.12	0.7099	533.	2.7275
8.2	1.9136	530	2.7246
1.20	0.0790	787	1.8985
4.89	0.6895	320	2.5011
.13	1.1304	88	0.9420
.81	1.9603	59	1.7719
1.70	0.2312	110	2.0928
22.2	1.3455	1470.	3.1571

2.08	0.3189		
1.23	0.0870		
.786	1.8899		
.19	1.2801		
[illegible]	0.0850		
.834	1.9210		
.21	1.3205		
1.5	0.8695		
1.11	0.0396		
.587	1.7688		
.845	1.6540		

100 mm = 3.28 ft log 3.28. 1.5159

10.4841 -10

$\frac{1}{3.28} = 3.049$ log = 0.4841

3.049 times as much wire in 1 foot than in 100 mm.

9 | 100 mm of wire weigh 1 mg

1 ft of same will weigh

.00098 oz

3.50772	
0.4841	
5.9913	

oz X 480 = grains log 480 2.6812

oz X 31.103 = mg log 31.103 4.4928

Ohms per foot of 1 mg in grain 84.8 1.8116

Ohms X 3.28 = 1.64 log 1.64 0.2148

1.6494	44.6
1.1923	15.5
0.7877	6.18
$\bar{1}.5945$	.393
0.1497	14.1
0.8703	7.43
$\bar{1}.6471$	.444
2.5085	322
0.9718	9.37
0.2999	2.00
$\bar{2}.0525$	.0113

1.8378	.688
7.3807	.24
$\bar{2}.9765$	.0946
$\bar{3}.7729$	.00592
$\bar{2}.3371$	.217
0.9688	.1878
3.8355	.00882
0.6969	4.97
7.1602	.1145
$\bar{2}.4888$	.0308
$\bar{4}.2409$	.00017

~~2000~~

$154000)\overline{2000.}$

.3010	300
2.1895	1875
2.1905	2.1135

2.1645 .0156

1897

2.1645	.3010
$\bar{3}.8355$ cts	.3010
$\bar{1}.0687$	2.1875
	2.1195
	2
	4.1195

$\bar{1}.0687$	2.1645
$\bar{3}.6355$	.9813
$\bar{1}.2332$	1.2332

17.1

No ohms in one oz

5.6694	71.4 1.8537
1.3222	0.2148
3.0216	1.6389
4.1265	6.8103
~~3.3218~~	5.1820
~~583~~	
$\bar{4}.5317$	~~360~~

Rect per foot	6.8103
feet per Ohm	1.3010
Cost per Ohm	4.1113

Cost per oz $2000 log = 1.3010

Wt. per 1000 mm in mg. 287	0.4579
1 foot of wire weighs	3.9913
	4.4492
Cost per foot	1.3010
	3.7502
feet in Ohm	3.6612
.000129 cost per Ohm	4.1114

43.5 ohm = 1 foot	1.6389
1 foot weighs	4.4492
	1.6389
1 ohm weighs oz	6.8103
in 1 oz there are ohms	5.1897
cost per oz	1.3010
	5.1897
	4.1113

50 cts per hour for 100 lamps

H.P. costs 2 cts

6 for H. P.

$\frac{100}{6}$ 2 cts = 33 cts

~~50 cts. per hour for 100 lamps~~

$6.00 for machine

$60.00 a year interest

365)60 1.7782

2 5623

1.2159

50 cts

3 hours each day .164 interest per day

.164 interest per day

$5.5 cts per hour for interest

100

a lamp turned 3 hours each day cost for gas at $1.50 per 1000

$\frac{1000}{15}$ 1.50 =

~~15~~ 3 30 ~~1000~~ ~~200~~ 40 1.50 $.90 40

400)9.0(.02

4.9

$\frac{1000}{5}$ = 9.0 $\frac{5}{1000}$ 1.50

$\frac{1}{200}$ $\frac{15}{20}$

$\frac{15}{20}$ $\frac{3}{4}$ ct per hour

1.00 1000

5 $\frac{1}{200}$ $1.00 per thousand

1.5 ct 3 hours

100 lamps

1.50 $1.50 $1.50 per evening

$1.50 for evening

100 365 100 lamp machine

182.5

547.50

Supposing as in the case of street lamps ~~these~~ what burned 10 hours a day

gas 100 per 1000 5 cts each

100 lamps ~~$5.00~~ 5 cts per hour

2 ct each .50

H. P. 1.5 ct per hour

6 lamps per H. P.

$\frac{100}{6}$ 1.5 cts ~~$2.00~~ per hour

100 × .25 cts per hour

for H. P. and expense

$600 for machine

interest and repairs $75

75	1.8751
3650	3.5623
	2.3128

.0205 cts per hour for interest on machine

Lamp costs $3.00

$300 for 100

$30 interest

Conductors for street lamps since the lamps may be put in series and have low resistance in each

$25 in all

$ 30.0	7.4771	
3650	3.5623	
~~.0823~~	3.9148	lamp
.00823		

$ 2.5	0.3979	
.000684	3.5623	conductors
	4.8356	

12 lamps a year broken

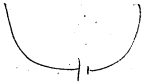
$36	1.5563
3650	3.5623
	3.9946
.0096	

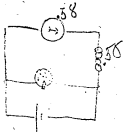
Total

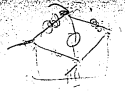
H. P. and Central Station running expenses

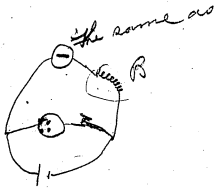
25
205
823
96
28971

30 cts.









41
20

49

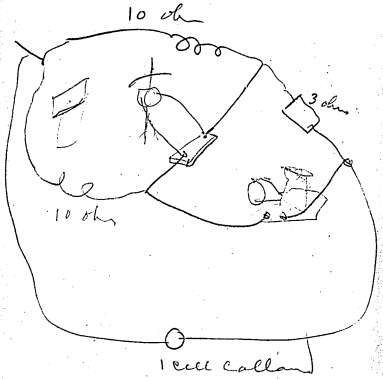
60
30

.00142 grains = how many Grammes

.00142 $\bar{3}.15229$
.06479 $\bar{2}.81104$
$\bar{5}.96335$

.0000919
.00001021 - Grammes of H.

Jenkin says
.00092


10 ohm
3 ohm
10 ohm
1 cell callan

Number 1
1/2 mile 38 ohm

2 178. 2

1

451

$\frac{1}{500}$

1	1.00
2	.50
4	.25
8	.12
15	.6
32	.3
64	$\frac{1}{2}$
128	.75
256	.37
512	.18
1024	.9
2048	$\frac{1}{2}$
4096	$\frac{1}{4}$
8192	$\frac{1}{8}$
~~16,350~~	

8000, 4 inch wire
100,000 of 1000 ohm

6

500
10
5000,

18000
24
72000
36000
32,000

50. 18000 / 360
1500
300
300

150 / 4000
300
1000
900

180 / 2300 / 28
160
700
640
60.

360.
200
72,000

3 / 360
120.
300
36,000

15.
15
3000
45000

50.000
40.000

1

17

200.000

24

Engine 100.000
50.000.
25

175.000.

35000

50

152

$15\frac{1}{2}$ — 90.

6000 feet for 1 dollar

600,000 100,

95

1,000

30 000

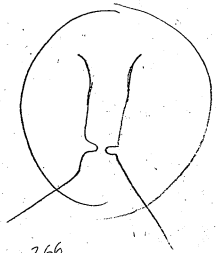
2 1 1/2

26000 1 1/2

26000 60

2 1 $\frac{1}{4}$

600,



266

$2\frac{1}{2}$